

Introduction to Interoperability Problem and Chainlink CCIP

Chainlink CCIP

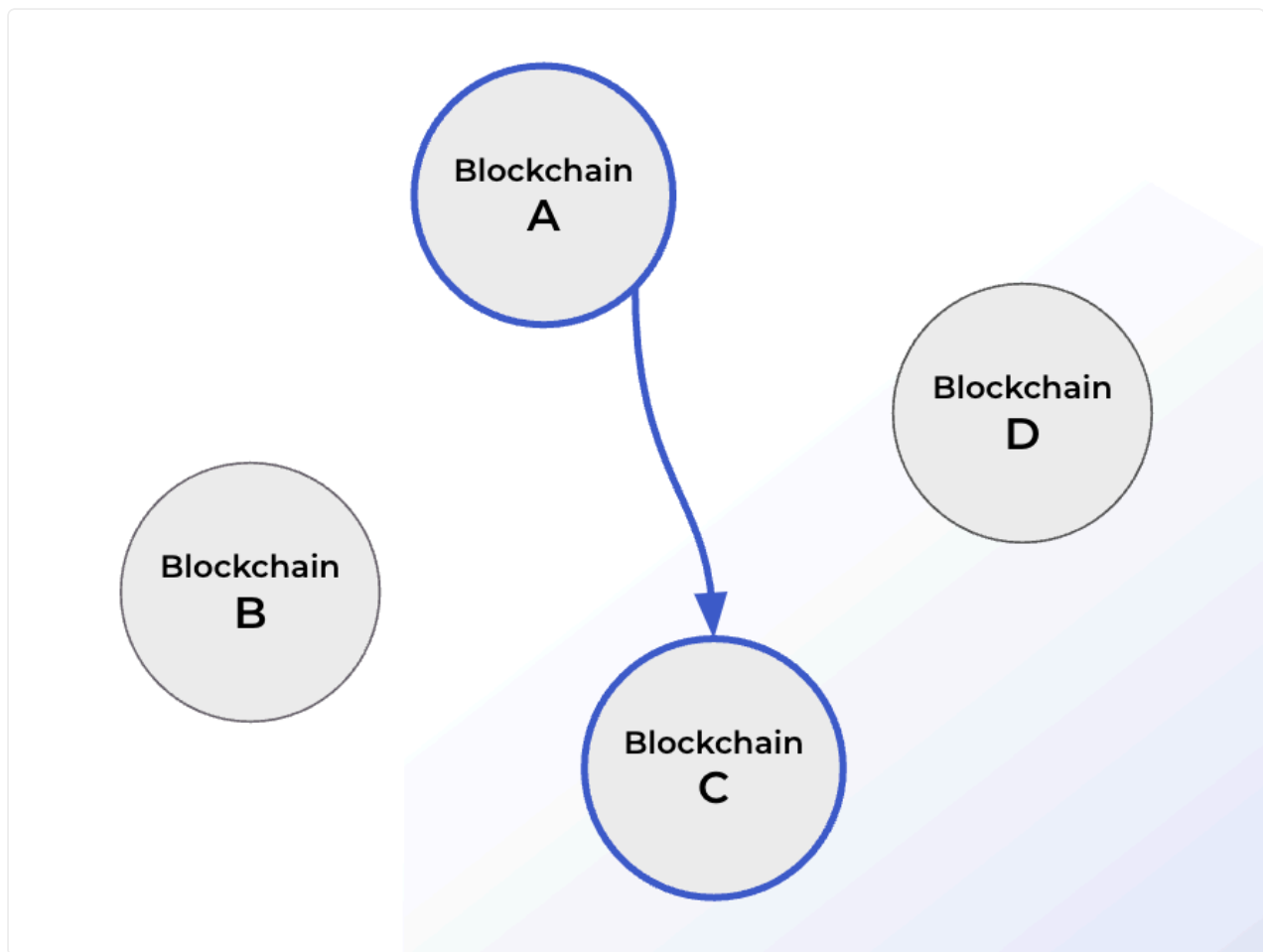
General overview of the Chainlink CCIP

The interoperability problem

Interoperability is the ability to exchange information between different systems or networks, even if they are incompatible. Shared concepts on different networks ensure that each party understands and trusts the exchanged information. It also considers the concept of *finality* to establish trust in the exchanged information by validating its accuracy and integrity.

The Web3 ecosystem has become multi-chain, with the rise of layer-1 blockchains and layer-2 scaling solutions like appchains, subnets, and more, where each network has its own approach to scalability, security, and trust.

However, blockchains are isolated networks that operate independently and cannot communicate natively. To create a truly interoperable Web3 ecosystem, data and value must move seamlessly between chains. This is where bridges come in.



Example of a traditional bridge

Traditional bridges are one of the biggest problems in today's Web3 ecosystem because they are centralized. When you are transferring funds from one chain to another using bridge, you are essentially giving your funds to some centralized entity, and you are trusting them that the funds will appear on the other side. And surprise, surprise, numerous bridge hacks have happened so far.

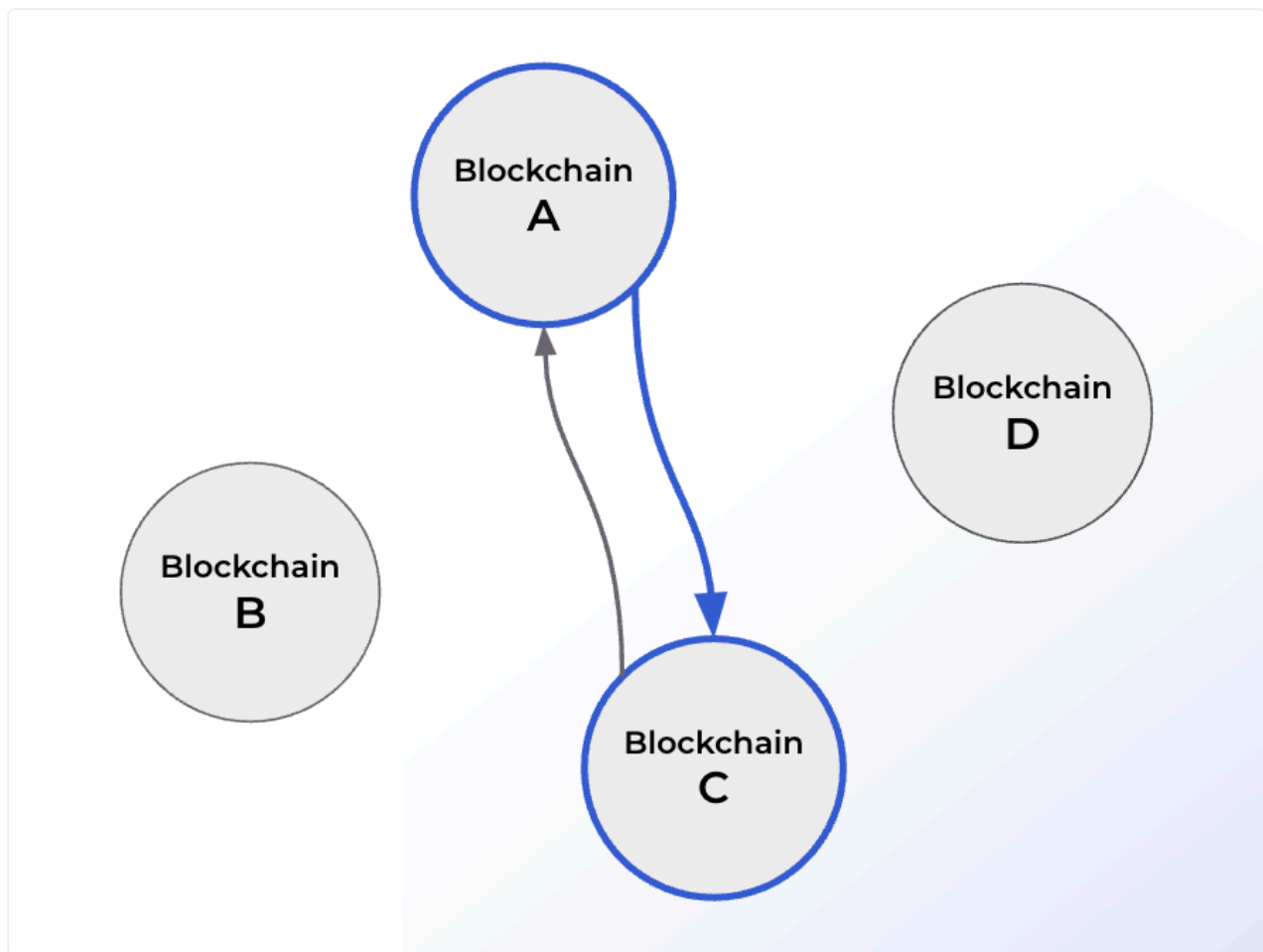


Trust assumptions - Patrick bridging funds

The solution - Chainlink CCIP

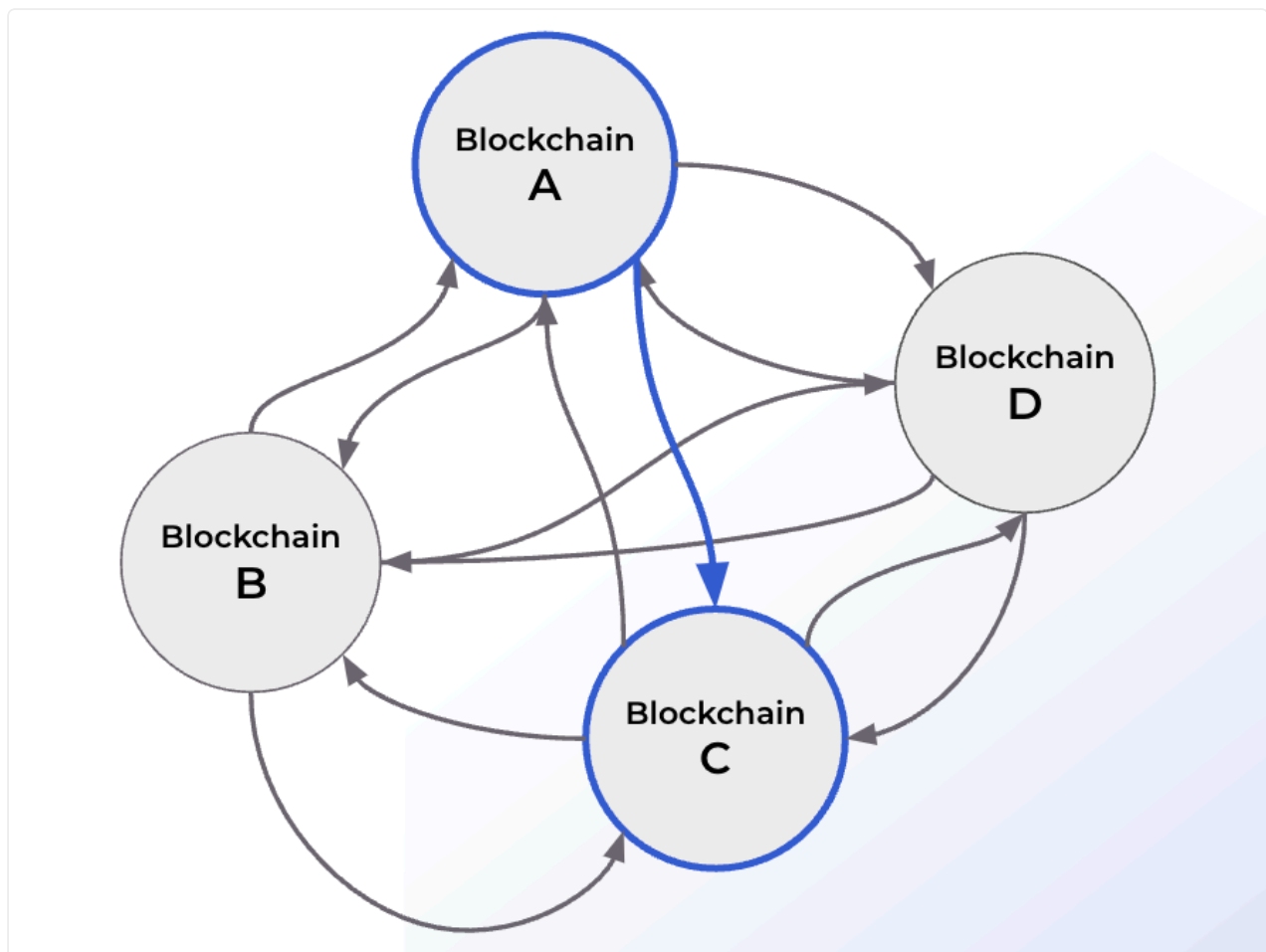
The *Chainlink Cross-Chain Interoperability Protocol (CCIP)* provides a single simple interface through which dApps and web3 entrepreneurs can securely meet all their cross-chain needs, including token transfers and arbitrary messaging.

Chainlink CCIP connects blockchain networks via **lanes**. The lane is a unique combination of source blockchain to destination blockchain path, e.g., from blockchain A to blockchain C. To transfer messages in reverse order, from blockchain C to blockchain A using Chainlink CCIP, you will need to use a different lane, the one which is unique to the C → A path.



Example of bi-directional CCIP lanes between two blockchains

Chainlink CCIP will always support bi-directional lanes for each new chain added in the future. The logical question is how CCIP knows through which lane to transfer a CCIP cross-chain message. It's actually quite simple - each blockchain supported by CCIP has a unique **chain selector**.



CCIP lanes

We said multiple times that by using Chainlink CCIP, you can send **cross-chain messages**. But what can a cross-chain message consist of? With Chainlink CCIP, one can:

- Transfer (supported) tokens
- Send any kind of data
- Send both tokens and data

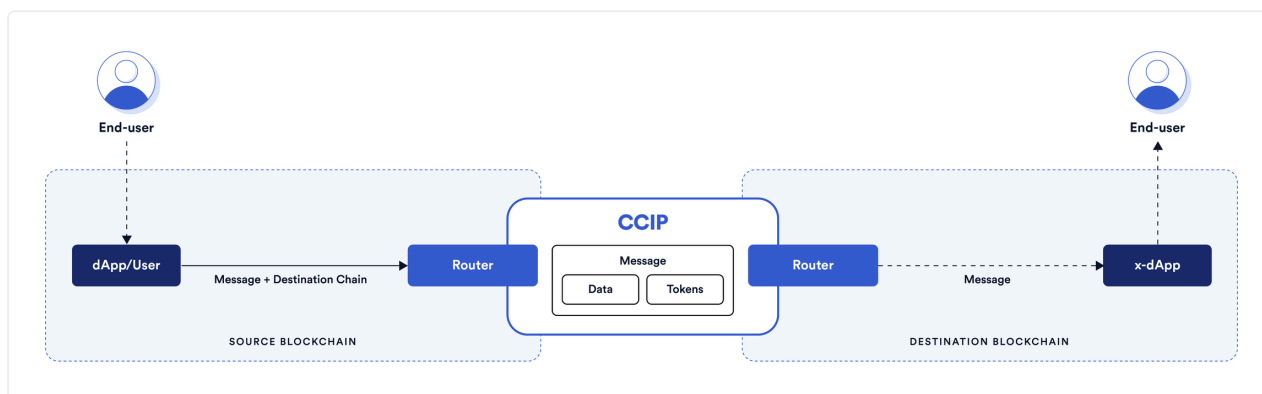
CCIP sender can be:

- EOA
- Any smart contract

CCIP receiver can be:

- EOA
-

- Any smart contract that implements `CCIPReceiver.sol`



Basic CCIP Architecture

Note: If you send a message and token(s) to EOA, only tokens will arrive.

For now, you can consider CCIP as a "black-box" component and be aware of the Router contract only. We will explain the Chainlink CCIP architecture in the following chapters.

The **Router** is the primary contract CCIP users interface with. This contract is responsible for initiating cross-chain interactions. One router contract exists per chain. When transferring tokens, callers have to approve the router contract to be able to "spend" (transfer) the caller's tokens. When a message is received on the destination chain, the router is the contract that "delivers" tokens to the user's account or the message to the receiver's smart contract.

Recap

The Chainlink Cross-Chain Interoperability Protocol provides a single interface to transfer tokens and data across multiple chains in a secure and decentralized manner.

New Terms	Meaning
Interoperability	The ability to exchange information between different systems or networks, even if they are incompatible
Chainlink CCIP	The protocol that allows you to send tokens and arbitrary messages across different blockchains

New Terms	Meaning
Lane	The unique combination of source blockchain to destination blockchain path
Chain Selector	The unique identifier of a blockchain in Chainlink CCIP
CCIP Message	The message that you can send across blockchains through CCIP lane which can consist of tokens and arbitrary data
Sender	A smart contract (of the User) or an EOA that sends the CCIP Message
Source blockchain	The blockchain the CCIP Message is sent from
Receiver	A smart contract or an EOA that receives the CCIP Message
Destination blockchain	The blockchain the CCIP Message is sent to

How CCIP Programmable Token Transfers Unlock Cross-Chain Innovation

The Chainlink Cross-Chain Interoperability Protocol (CCIP) is far more than a simple token bridging solution. It's a generalized cross-chain messaging protocol for transferring tokens (value), messages (data), or both tokens and messages simultaneously within a single cross-chain transaction—referred to as Programmable Token Transfers.

In effect, CCIP Programmable Token Transfers enable smart contracts to transfer tokens cross-chain along with instructions on what the receiving smart contract should do with those tokens once they arrive on the destination chain. This revolutionary concept of wrapping value and instructions together allows tokenized value to interact automatically and dynamically once it arrives at a destination, opening up a world of new possibilities.

In decentralized finance (DeFi), CCIP Programmable Token Transfers enable the creation of cross-chain native dApps, such as a smart contract that can automatically transfer tokens cross-chain and deposit them into the highest yield lending markets. Within traditional finance (TradFi), CCIP Programmable Token Transfers enable advanced use cases, such as a cross-chain delivery-vs-payment (DvP) transaction where an institution holding stablecoins on its private blockchain can purchase a tokenized asset issued on a different private or public chain.

Importantly, CCIP Programmable Token Transfers enable institutions to interact with [smart contracts](#) and [tokenized assets](#) on other blockchain networks without needing to integrate or directly interact with that blockchain. All they need to do is send instructions to CCIP on how to interact with that chain, greatly reducing their overhead and the risks associated with point-to-point integrations with each blockchain network.

“This is the pinnacle of our achievement so far ... The value and the message moving together is revolutionary.”
—Nigel Dobson, Banking Services Lead at ANZ

CCIP Supports Any Cross-Chain Transfer Involving Both Data and Value

Just as TCP/IP is a universal standard that underpins the Internet, Chainlink CCIP serves as a universal standard that underpins the [Internet of Contracts](#). To support all the various cross-chain use cases that exist within DeFi and TradFi, CCIP allows for a variety of ways to transfer data and/or value across blockchains.

Arbitrary Messaging

CCIP's support for [Arbitrary Messaging](#) enables developers to transfer any arbitrary data (encoded as bytes) across blockchain networks. Developers utilize CCIP's Arbitrary Messaging to make their smart contract applications cross-chain native.

With CCIP, smart contracts on a source chain can call any arbitrary function on any arbitrary smart contract on a destination chain to trigger any arbitrary action (and receive a callback on the source chain if needed). Developers can encode multiple instructions in a single message, empowering them to orchestrate complex, multi-step, multi-chain tasks.

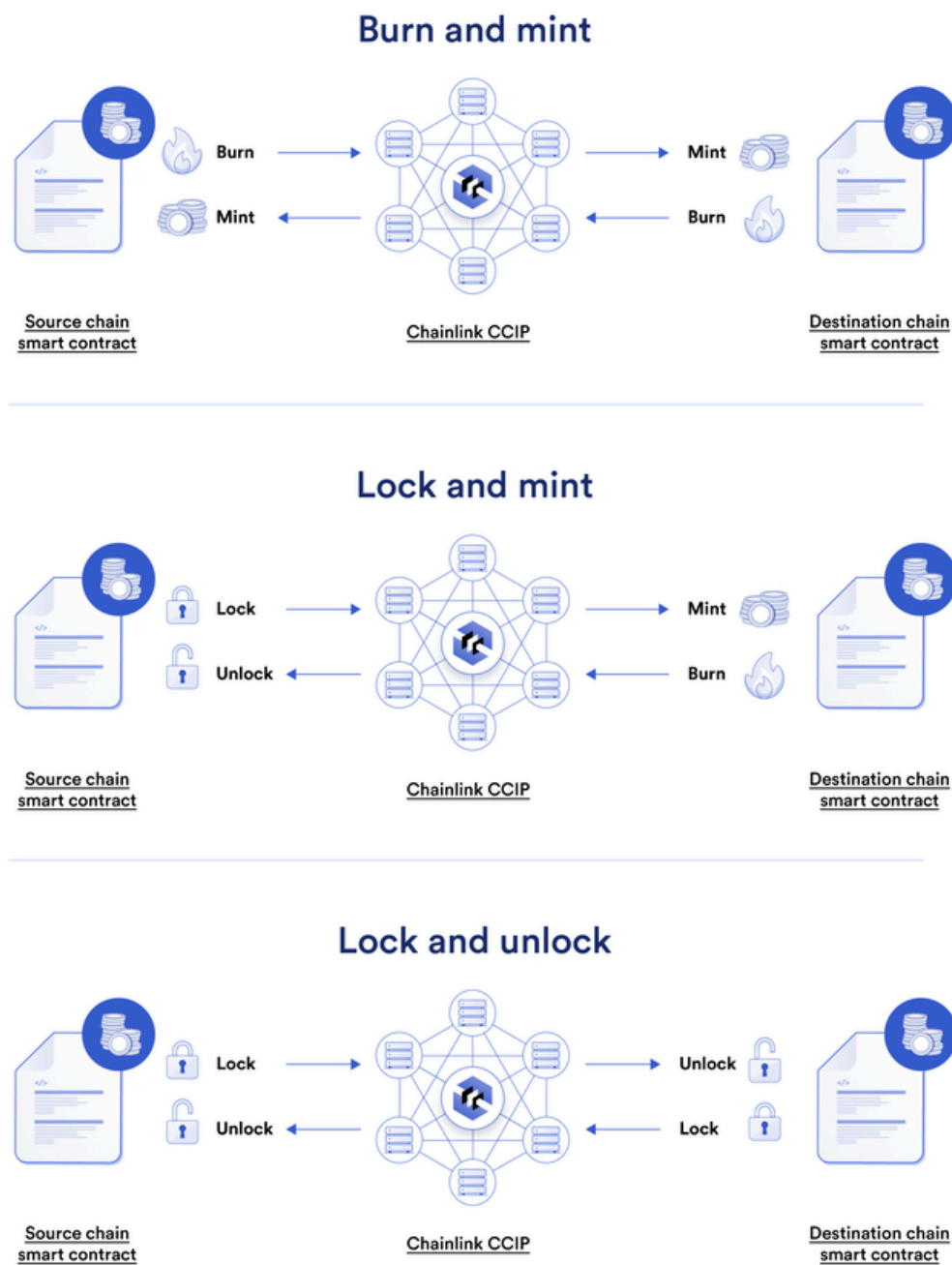
Token Transfers

CCIP Token Transfers enable the transfer of tokens between chains via highly audited and security-reviewed token pool contracts. Transactions can be initiated directly by externally owned accounts (EOAs), such as from user wallets via a bridging app like [Transporter](#), or directly by a smart contract. Tokens can then be sent to an EOA or to a smart contract.

In order to ensure the highest level of security and a superior user experience, token issuers can use CCIP directly within their token's smart contract to make it a native cross-chain token. As a result, any user or developer can use CCIP to transfer the official (canonical) version of that issuer's token cross-chain. Various layer-1 blockchain and layer-2 rollups such as Wemix and Metis built upon this concept by integrating [CCIP as their official cross-chain infrastructure](#) to power their canonical token bridges. Every token transferred onto those blockchain networks via CCIP is the canonical representation of that token on that chain.

There are three primary ways developers can integrate CCIP for token transfers:

- **Burn and mint**—Tokens are burned on a source chain, and an equivalent amount is minted on a destination chain. This enables the creation of cross-chain native tokens with a dynamic, unified supply across chains. [CCIP supports Circle's USDC](#) via the burn and mint token transfer method.
- **Lock and mint**—Tokens are locked on the chain they were natively issued on, and fully collateralized "wrapped" tokens are minted on destination chains. These wrapped tokens can be transferred across other non-native destination chains via burn and mint or be burned to unlock tokens back on the original issuing source chain. [Truflation's TRUF](#) token utilizes lock and mint for its token transfers on CCIP.
- **Lock and unlock**—Tokens are locked on a source blockchain, and an equivalent amount of tokens are released on the destination blockchain. This enables the support of tokens without a burn/mint function or tokens that would introduce challenges if wrapped, such as native blockchain gas tokens. CCIP supports [native ETH transfers](#) via the lock and unlock token transfer method.

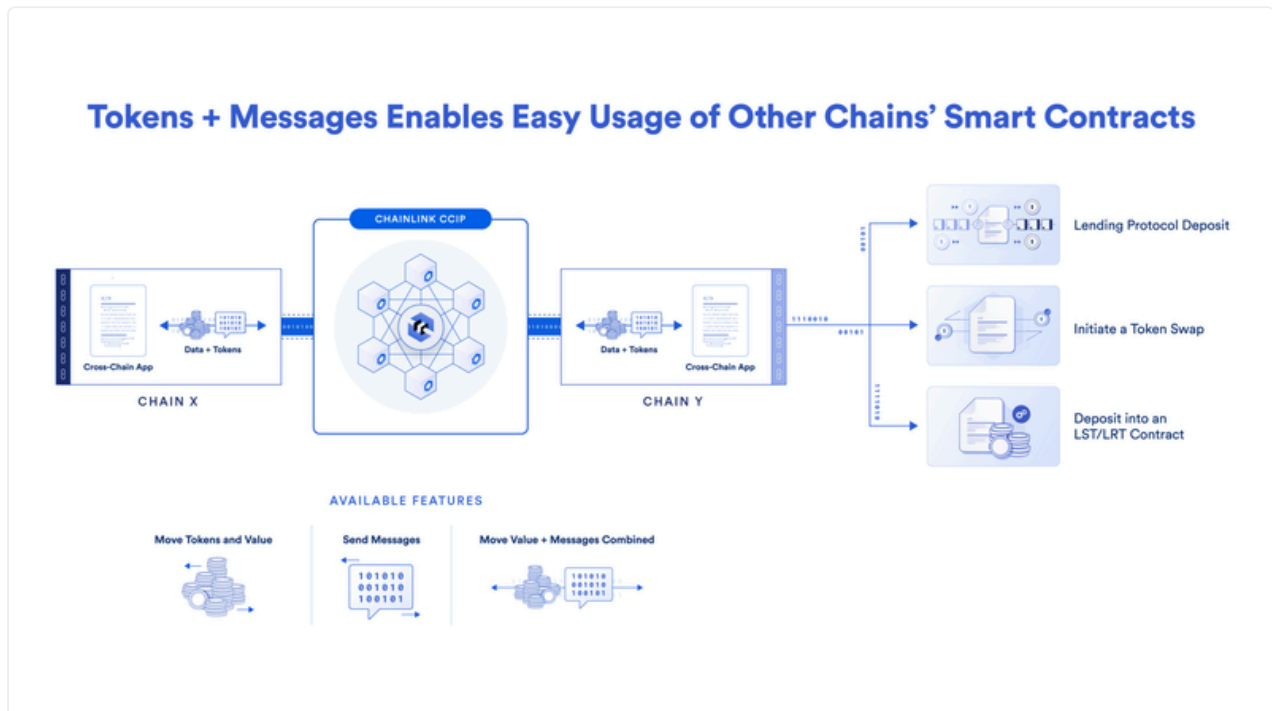


CCIP is purpose-built to support cross-chain token transfers across a wide range of assets and applications.

Programmable Token Transfers

Programmable Token Transfers combine Token Transfers with Arbitrary Messaging. This enables developers to transfer both tokens (value) and instructions (data) about what to do with those tokens cross-chain within a single transaction. Importantly, Programmable Token Transfers are built natively into CCIP to give

users the best possible security, reliability, UX (e.g., composability), and risk management.



Programmable Token Transfers enable tokens and messages to be sent cross-chain as part of a single transaction, improving the developer and user experience.

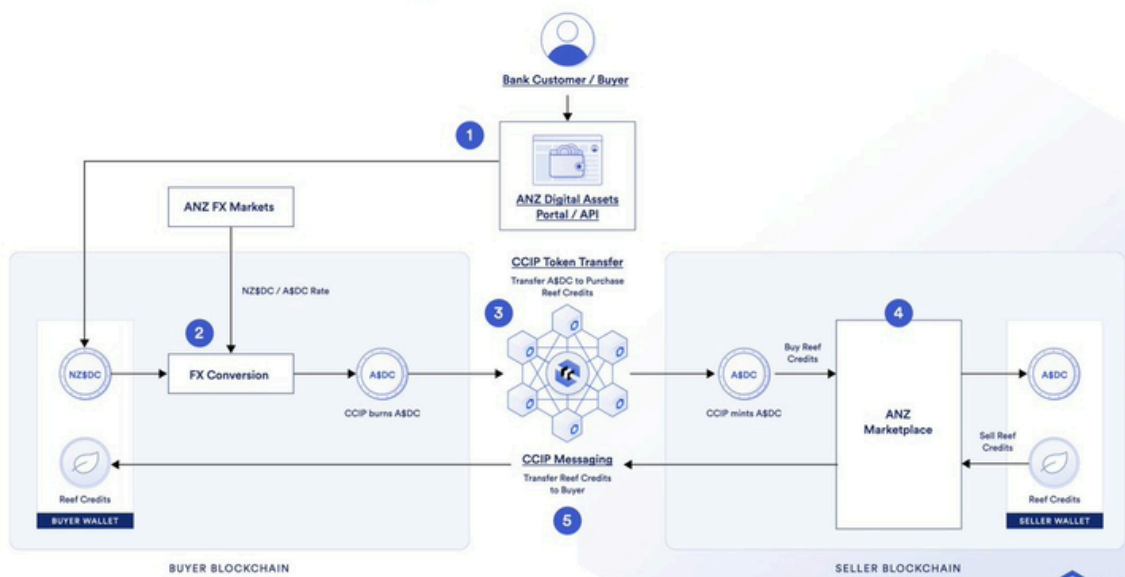
CCIP Programmable Token Transfers in TradFi

CCIP Programmable Token Transfers are critical to enabling cross-chain [Delivery vs. Payment \(DvP\) transactions](#). DvP in traditional finance refers to the requirement that the delivery of assets (e.g., securities) and the payment for those assets happen simultaneously (i.e., atomic settlement). DvP is an important feature in reducing the risk that a counterparty won't deliver on its leg of the transaction despite the other leg being fulfilled.

[The Australia and New Zealand Banking Group Limited \(ANZ\)](#) demonstrated how CCIP Programmable Token Transfers can enable a cross-border, cross-chain, cross-currency DvP transaction. In a single cross-chain transaction, a stablecoin backed by a local currency (NZ\$DC) was converted to another stablecoin in a different national currency (A\$DC), transferred from the buyer's source chain to the seller's destination chain along with the instruction to purchase a tokenized asset (e.g., reef credits), which was subsequently sent back to the customer's wallet on the source chain.

To learn more, check out the case study [Cross-Chain Settlement of Tokenized Assets Using CCIP](#) written in collaboration with ANZ and the [Sibos panel discussion](#) between Chainlink Co-Founder Sergey Nazarov and ANZ's Banking Services Lead Nigel Dobson.

ANZ & CCIP: Cross-Currency, Cross-Chain Settlement of Real-World Assets



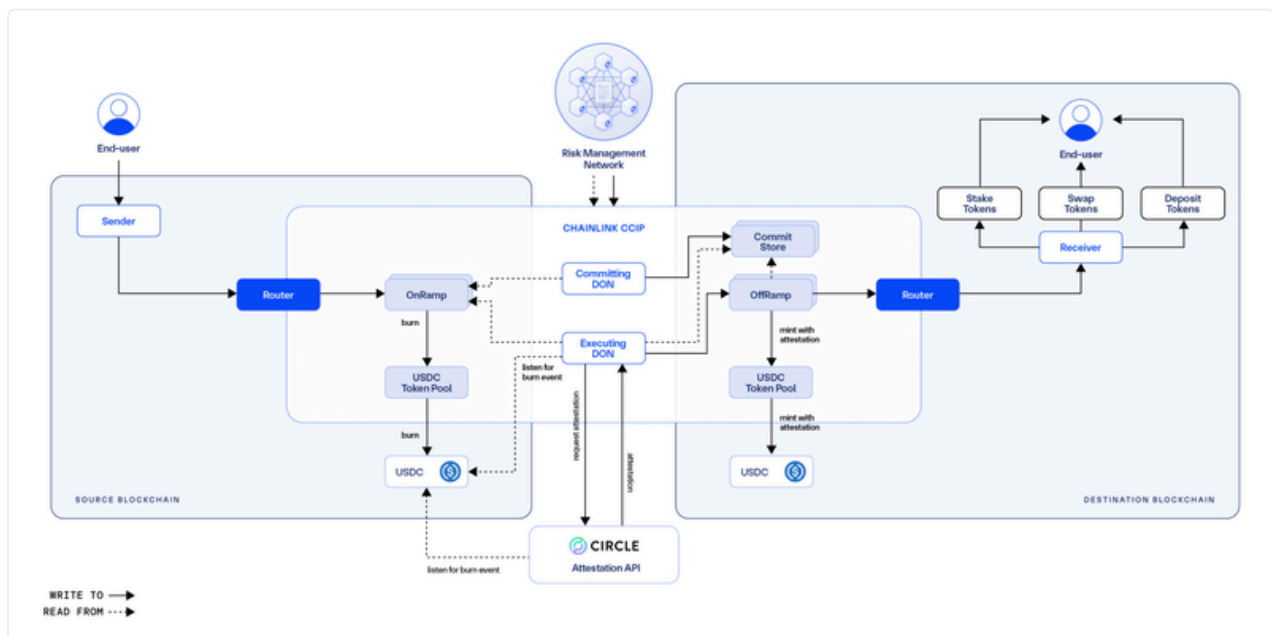
ANZ used CCIP to showcase a cross-currency, cross-chain settlement of tokenized assets using stablecoins.

CCIP Programmable Token Transfers in DeFi

Cross-Chain Swaps

CCIP Programmable Token Transfers enable cross-chain swap use cases, where any token can be effectively bridged over CCIP by connecting to liquidity pools / DEXs on the source and destination chains.

For example, a cross-chain swap app built on CCIP enables users holding Token A on Arbitrum to be swapped for Token B on Optimism by first swapping Token A on Arbitrum for USDC, bridging the USDC to Optimism along with data about the swap, and then automatically swapping the USDC to Token B and sending it to the user's wallet. This is why [CCIP's support for native USDC](#) is so powerful; it doesn't just support the cross-chain transfer of native USDC via burn and mint, but also the simultaneous transmission of data on what to do with the USDC once it arrives on the destination chain—a unique feature of CCIP Programmable Token Transfers.



Chainlink CCIP enables Programmable Token Transfers across blockchains involving the USDC stablecoin.

[XSwap](#) is a cross-chain swaps protocol and [BUILD](#) participant that uses CCIP for Programmable Token Transfers to enable cross-chain swaps between blockchain

networks. USDC is used as the liquidity token for XSwap. Since its launch, XSwap users have initiated over \$130M in CCIP Programmable Token Transfers.

Other users of CCIP Programmable Token Transfers include [Transporter](#), [ChainSwap](#), [WEMIX PLAY](#), [Amino Rewards](#), and more.

Cross-Chain Staking and Restaking

CCIP Programmable Token Transfers unlock innovation for [cross-chain staking and restaking](#). End-users can stake/restake assets directly from a layer-2 network, where CCIP is used to transfer the native assets back to the layer-1 blockchain chain along with instructions to (re)stake the asset in a specified (re)staking protocol. This reduces gas costs for users and provides them the convenience to (re)stake from any chain.

For example, [EigenPie is integrating Chainlink CCIP](#) to enable its users to deposit ETH directly into their layer-2 contracts in order to receive the corresponding LRT (egETH) without ever having to leave the chain. Once users deposit ETH into the layer-2 contract, CCIP's Programmable Token Transfers will bridge the tokens to Ethereum with instructions to restake them into Eigenlayer. CCIP is then used to lock the minted egETH on Ethereum and bridge it back to the L2 where it is minted and sent to the end user's wallet address.

You can read more about Chainlink's support for staking and restaking in the blog: [How The Chainlink Platform Unlocks LST and LRT Adoption in DeFi](#). Learn how to implement Chainlink CCIP Programmable Token Transfers in the [CCIP Masterclass: Cross-Chain Staking Edition](#) for a more technical deep dive.